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Original Communication

Distribution of body mass index in the forensic victim population: Comparison with the general population and relation to manner of death

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ABSTRACT

Despite a dramatic increase in the worldwide prevalence of overweight and obese people in recent years, the implication of this epidemic on forensic practice has barely been studied. Over a one-year period, all autopsy cases performed on adult victims in the province of Quebec (Canada) were retrospectively reviewed (582 cases). In the forensic population, manner of death differed in relation to BMI: underweight people most commonly died of natural causes, whereas normal weight, overweight and obese individuals most commonly died as the result of an accident. Results also revealed an over-representation of underweight victims and under-representation of overweight victims in the forensic population compared to the population of both Quebec and Canada. The latter is particularly worrisome considering it suggests that overweight corpses are less frequently referred for an autopsy. It is important to emphasize to forensic teams that just because an obese person is more likely to suffer from health problems that can lead to death, does not mean a natural death has occurred. Obese people are equally susceptible to unnatural causes of death and it is crucial to maintain an adequate level of suspicion while investigating the cases of these individuals.

The prevalence of overweight and obese individuals, all over the world, has dramatically increased in recent years. In fact, the Word Health Organization (WHO) considers this phenomenon as a global epidemic.[1] Worldwide, an estimated 1 billion adults are overweight including 300 million people in the obese category.[2] In North America, the situation is similar.[3–6] In 2004, approximately 5.5 million Canadian adults (23.1%) were obese and an additional 8.6 million Canadians (36.1%) were overweight, while two thirds of American adults were overweight or obese (66.3%, including 32.2% obese).[5,4] This epidemic situation is taken very seriously by the WHO and many governments because the consequences associated with excess body weight have a negative impact on life expectancy and health.[1,3,5,7-10] Overweight people are at an increased risk of developing type 2 diabetes, cardiovascular disease, hypertension, stroke, certain forms of cancer, osteoarthritis, gallbladder disease, breathing problems and psychosocial problems.[1,3,5,7,10-14] Although less prevalent, being underweight also poses serious health problems by increasing the risk of cardiovascular, cerebrovascular and respiratory diseases, osteoporosis, diseases of the central nervous system, infertility and impaired immunocompetence.[3,11,13-15]

Despite reaching an epidemic level, the impact of the increasing demographic of overweight and obese people on forensic practice has barely been studied. Authors have shown that there is an increasing trend in the average body mass index of forensic victims in both Australia and the United Kingdom.[16,17] Considering the increased risk of sudden death in both overweight and underweight individuals, it could be hypothesized that this portion of the population would be over-represented among forensic autopsy victims.[12,15] The aim of the present study was to evaluate if the prevalence of overweight and obese adults in the forensic victim population mirrors the global epidemic proportionally or if those cases are indeed over-represented. The proportion of underweight victims among the forensic population will also be compared to that of the general population. Finally, manner of death will be considered in relation to body weight.

2. Materials and methods

In the Province of Quebec, Canada, all forensic autopsies are performed at a centralized laboratory, the *Laboratoire de sciences*

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Table 1
Comparison of the forensic victim population to the general population of Quebec and Canada.

BMI Categories	Forensic	Quebec[a]	Canada[a]
Underweight	9.4%	2.2%	2.0%
Normal Weight	40.8%	41.4%	38.9%
Overweight and Obese	50.3%	56.4%	59.1%
Overweight	28.8%	34.5%	36.1%
Obese	20.9%	21.9%	23.1%
Average BMI	25.7	26.7	27.0

[a] References.[5,7]

judiciaires et de médecine légale located in Montreal. In a one-year period (2005), all autopsy cases of victims aged 18 years and older were retrospectively reviewed (582 cases). Of these, all victims with significant post-mortem changes (charred, skeletal, decomposed or mummified bodies) were excluded from the analysis because an accurate measurement of body height and weight was not possible (114 cases). Overall, a total of 468 cases (348 were males and 120 were females) were considered for the present study. The sex, age, race, weight and height of the victims were compiled and their body mass indexes (BMI) were calculated according to the following formula: weight in kilograms divided by the square of the height in metres.[1] According to BMI, victims were divided into four categories as outlined by the WHO: underweight (BMI $<$ 18.5), normal weight (18.5 $\geq$ BMI $\leq$ 24.9), overweight (25.0 $\geq$ BMI $\leq$ 29.9) and obese (BMI $\geq$ 30.0).[1] BMIs in our forensic victim population were then compared with available data for the general population in our province and country.[5,7] Furthermore, manner of death was also recorded and analyzed in relation to BMI.

3. Results

3.1. BMI categories

In our forensic population, the majority of victims are overweight or obese (50.3%). More precisely, about 9.4% are underweight, 40.8% normal weight, 28.8% overweight and 20.9% obese. In Table 1, the results are presented in comparison to the general population of both Quebec and Canada. Interestingly, the forensic victim population seems to be different from the general population, with an over-representation of underweight individuals. As a matter of fact, the prevalence of underweight adults in the forensic victim population is more than four times higher than in the general population (9% compared to 2% in both Quebec and Canada). On the other hand, an analysis of the exact confidence interval for binomial populations[18] suggests that overweight people are under-represented; 29% (95%CI: 24.8%–33.2%) of the forensic victim population is overweight compared to 35% of Quebec residents and 36% of Canadians. As for normal weight and obese individuals, their prevalence in the forensic and general population is similar. The average BMI of forensic victims is about 1 kg/m^2 lower than the average BMI of residents of Quebec and Canada. This lower average BMI suggests the over-representation of underweight people and the under-representation of overweight people in the forensic population.

Table 2
BMI categories in relation to gender.

BMI Categories	Male (%)			Female (%)		
	Forensic	Quebec[a]	Canada[a]	Forensic	Quebec[a]	Canada[a]
Underweight	6.0	1.7	1.4	19.2	2.7	2.5
Normal Weight	39.7	36.6	33.6	44.2	46.1	44.1
Overweight and Obese	54.3	61.7	65.0	36.7	51.2	53.4
Overweight	32.2	41.1	42.0	19.2	28.1	30.2
Obese	22.1	20.6	22.9	17.5	23.1	23.2

[a] References.[5,7]

3.2. BMI categories in relation to gender, age and race

The over-representation of underweight individuals in the forensic victim population is common to both males and females, though the proportion of underweight victims is higher among females ($\chi^2 = 18.07, df = 1, N = 468, p < .001$) (Table 2). Underweight male victims are over-represented by more than four times (6.0%, 95%CI: 3.8%–9.1%) the average from Quebec and Canada, while underweight female victims are over-represented six fold (19.2%, 95%CI: 12.6%–27.4%). This under-representation is particularly striking for female victims. Despite more than half of the female population of Quebec (51%) and Canada (53%) being either overweight or obese, only 37% (95%CI: 28.1%–46.0%) of forensic victims fall into those weight categories combined. The BMI categories in relation to age and in relation to age and gender are presented in Tables 3 and 4 respectively. A comparison of BMI to age reveals that overweight people are under-represented in the forensic population of adults of 35 years or more (95%CI: 46.8%–57.4%), but not in younger adults of less than 35 years of age. The overwhelming majority of the forensic victims were Caucasian; nevertheless, BMI in relation to the victim's race is portrayed in Table 5.

3.3. BMI in relation to manner of death

Overall, 33% of the victims died of an accident (154 cases), 23% committed suicide (108 cases), 21% died of natural causes (100 cases) and 18% died of homicide (85 cases). In 5% (21 cases), the manner of death was not determined. Interestingly, natural death is the most common manner of death among underweight victims (43%), whereas it ranks third place for overweight and obese victims (19%) and fourth place for normal weight individuals (19%) (Table 6). The most common manner of death for normal weight, overweight and obese individuals is an accident.

The predominance of natural death among underweight victims is striking for both males and females. Almost half of the underweight males (48%) and 39% of underweight females died of natural causes (Table 7). On the other hand, males and females with normal or excessive weight in our forensic victim population tended to die more commonly from accidents.

4. Discussion

Despite the fact that obesity and being overweight has reached an epidemic level, the impact on forensic practice has barely been studied.[1] As far as we know, this is the first study to systematically evaluate the BMIs of victims in the forensic setting in comparison to the general population to determine if the distribution is similar. This study is also unique with respect to the comparison of manner of death to BMI.

In the Province of Quebec, Canada, approximately half of the forensic victims are overweight or obese (50.3%). However, the distribution of BMI among the forensic victim population differs from that of the general population, with an over-representation of underweight and an under-representation of overweight individuals. The over-representation of underweight adults is particularly striking, the prevalence of underweight victims in the forensic population being fourfold higher than in the general population. Furthermore, this over-representation of underweight victims is observed for both males and females, though it was more pronounced for female victims. Considering that being underweight is associated with a higher risk of sudden death, the over-

Table 3
BMI categories in relation to age groups.

BMI Categories	Age Group													
	18–24		25–34		35–44		45–54		55–64		65–74		75 and older	
	# Cases	%	# Cases	%	# Cases	%	# Cases	%	# Cases	%	# Cases	%	# Cases	%
Underweight	1	2.3	6	9.0	6	5.9	10	8.7	8	11.4	5	13.5	8	24.2
Normal Weight	27	61.4	30	44.8	38	36.6	49	42.6	23	32.9	12	32.4	13	39.4
Overweight and Obese	16	36.4	33	46.3	58	57.4	56	48.7	39	55.7	20	54.1	12	36.4
Overweight	11	25.0	20	29.9	31	30.7	31	27.0	21	30.0	14	37.8	7	21.2
Obese	5	11.4	11	16.4	27	26.7	25	21.7	18	25.7	6	16.2	5	16.2

In gray: results significantly lower for forensic victims compared to the Canadian population.
Note: there was no Canadian comparative data for underweight and normal weight.

Table 4
BMI categories in relation to age and gender.

BMI Categories	Age Group													
	18–24		25–34		35–44		45–54		55–64		65–74		75 and older	
	# Cases	%	# Cases	%	# Cases	%	# Cases	%	# Cases	%	# Cases	%	# Cases	%
Male														
Underweight	0	0.0	2	4.0	2	2.5	8	8.8	3	6.0	3	12.5	3	20.0
Normal Weight	24	63.2	23	46.0	24	30.4	33	36.3	16	32.0	10	41.7	8	53.3
Overweight and Obese	14	36.8	28	50.0	53	67.0	51	55.0	31	62.0	11	46.0	4	26.3
Overweight	10	26.3	18	36.0	28	35.4	28	30.8	17	34.0	9	37.7	2	13.3
Obese	4	10.5	7	14.0	25	31.6	22	24.2	14	28.0	2	8.3	2	13.3
Female														
Underweight	1	16.7	4	23.5	4	18.2	2	8.3	5	25.0	2	15.4	5	27.8
Normal Weight	3	50.0	7	41.2	13	59.1	16	66.7	7	35.0	2	15.4	5	27.8
Overweight and Obese	2	33.4	6	35.3	5	22.7	6	25.0	8	40.0	9	69.3	8	44.5
Overweight	1	16.7	2	11.8	3	13.6	3	12.5	4	20.0	5	38.5	5	27.8
Obese	1	16.7	4	23.5	2	9.1	3	12.5	4	20.0	4	30.8	3	16.7

In gray: results significantly lower for forensic victims compared to the Canadian population.
Note: there was no Canadian comparative data for underweight and normal weight.

representation of this BMI category in the forensic victim population comes as no surprise.[15] This is in keeping with our finding that natural death was indeed the most common manner of death among underweight victims.

On the other hand, the proportion of overweight males and females is significantly lower in the forensic population of adults aged $\geq$35 years old compared to the general population. This under-representation of overweight people in our forensic victim population is troublesome. Considering that overweight and obese individuals are associated with an increased risk of sudden death, one may expect that those BMI categories would have also been over-represented in the forensic victim population.[12] Instead, an under-representation of overweight individuals is observed. Moreover, the most common manner of death in overweight and obese forensic victims is an accident (35%), followed by suicide (24%). Natural death accounts for only 19% of victims with excessive weight. This rate of natural death is lower than expected considering that the rate among normal weight victims is 20%. In the Province of Quebec, Canada, forensic autopsies are requested by coroners in cases of violent or suspicious deaths, while autopsies that are probably due to natural causes are generally performed in the hospital setting. Given the well-known association between excess body weight and serious health problems, such as cardiovascular disease and diabetes, perhaps the deaths of overweight

Table 5
BMI categories in relation to race.

BMI Categories	Caucasian		Negroid		Asian		Native		Undetermined	
	# Cases	%	# Cases	%	# Cases	%	# Cases	%	# Cases	%
Underweight	41	9.5	0	0.0	1	16.7	0	0.0	2	14.3
Normal Weight	176	40.7	5	55.6	1	16.7	4	57.1	5	35.7
Overweight and Obese	218	49.7	4	44.4	4	66.7	3	42.9	7	50.0
Overweight	122	28.2	3	33.1	3	50.0	2	28.6	5	35.7
Obese	93	21.5	1	11.1	1	16.7	1	14.3	2	14.3
Average BMI	25.7		26.8		24.9		25.3		24.9	

Table 6
BMI categories in relation to manner of death.

BMI Categories	Natural death	Accident	Suicide	Homicide	Undetermined	Total
Underweight	19 (43.2%)	10 (22.7%)	6 (13.6%)	5 (11.4%)	4 (9.1%)	43 (100%)
Normal Weight	37 (19.4%)	62 (32.5%)	45 (23.6)	40 (20.9%)	7 (3.7%)	190 (100%)
Overweight and Obese	44 (18.7%)	83 (35.3%)	57 (24.3%)	41 (17.4%)	10 (4.3%)	235 (100%)
Overweight	24 (17.8%)	47 (34.8%)	34 (25.2%)	24 (17.8%)	6 (4.4%)	136 (100%)
Obese	20 (20.4%)	36 (35.7%)	23 (23.5%)	16 (16.3%)	4 (4.1%)	99 (100%)
Average BMI	25.1	26.1	25.9	25.2	26.7	25.7

Table 7
BMI categories in relation to manner of death in males and females.

BMI Categories	Natural death	Accident	Suicide	Homicide	Undetermined	Total
Male						
Underweight	10 (47.6%)	3 (14.3%)	2 (9.5%)	4 (19.0%)	2 (9.5%)	21 (100%)
Normal Weight	27 (19.6%)	48 (34.8%)	32 (23.2%)	26 (18.8%)	5 (3.6%)	138 (100%)
Overweight and Obese	37 (19.5%)	67 (35.3%)	45 (23.7%)	32 (16.8%)	9 (4.7%)	190 (100%)
Overweight	21 (18.8%)	36 (32.1%)	30 (26.8%)	19 (17.0%)	6 (5.4%)	112 (100%)
Obese	16 (20.8%)	30 (39.0%)	15 (19.5%)	13 (16.9%)	3 (3.9%)	77 (100%)
Average BMI	26.0	26.6	26.1	25.7	28.0	26.3
Female						
Underweight	9 (39.1%)	7 (30.4%)	4 (17.4%)	1 (4.3%)	2 (8.7%)	23 (100%)
Normal Weight	10 (18.9%)	14 (26.4%)	13 (24.5%)	14 (26.4%)	2 (3.8%)	53 (100%)
Overweight and Obese	7 (15.9%)	16 (36.4%)	12 (27.3%)	8 (18.2%)	1 (2.3%)	44 (100%)
Overweight	3 (13.0%)	11 (47.8%)	4 (17.4%)	5 (21.7%)	0 (0.0%)	23 (100%)
Obese	4 (19.0%)	5 (23.8%)	8 (38.1%)	3 (14.3%)	1 (4.8%)	21 (100%)
Average BMI	22.5	24.4	25.4	23.8	22.4	24.0

patients are more likely to be presumed to be due to natural causes.[1,3,5,10] These presumptions can be based on actual medical records of the deceased person or sometimes only on the general statement that overweight people are more prone to die from natural sudden deaths. It should be emphasized however, that excess body weight does not protect someone from a violent traumatic death and forensic teams should be careful not to overlook these cases. Indeed, a lower rate of natural death in overweight victims compared to normal weight victims is wearisome, since it suggests that the level of suspicion of foul play is lower in overweight victims. This study serves as a warning of the potential bias in case assessment. While assessing a case, great caution should be exercised by coroners and medical examiners to maintain an appropriate level of suspicion despite the presence of obesity.

Conflict of interest

None.

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Ethical approval

According to the particularity of our jurisdiction, research done under the Coroner Law (the Coroner representing the deceased).

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